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This study investigates the role of specific inhibitory processes in lexical ambiguity resolution. An attentional view of inhibition and a view based on specific automatic inhibition between nodes predict different results when a neutral item is processed between an ambiguous word and a related target. Subjects were 32 English speakers with normal or corrected vision and with no reading disabilities. Stimuli of 120 ambiguous words were presented by an Apple II computer system to each subject. Subjects performed a lexical decision on long lists of targets presented one word at a time. The results suggest that contextually inappropriate meanings are suppressed by specific inhibitory processes, but they do not rule out the role of attention in the overall process of resolving ambiguous word meanings. (Author/JAZ)

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Cognitive Science Program

PROCESSES IN THE PRODUCTION OF ARBITRARY VERBS: EVIDENCE FOR A MODEL OF SEQUENTIAL INHIBITION

BY

PETER [illegible]

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An experiment using a lexical decision paradigm is reported investigating the role of specific inhibitory processes in lexical ambiuity resolution. An attentional view of inhibition and a view based on specific automatic inhibition between nodes predict different results when a neutral item is processed between an ambiguous word and a related target. The results suggest that contextually inappropriate meanings are supressed by specific inhibitory processes, but they do not rule out the role of attention in the overall process of resolving ambiguous word meanings. A tentative model of selective inhibitory processes is discussed in relation to these experiments.

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Processes in the Resolution of Ambiguous Words: Towards a Model of Selective Inhibition

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Processes in the Resolution of Ambiguous Words:
Towards a Model of Selective Inhibition

In describing psychological phenomena psychologists have borrowed several terms from neuroscientists. Among these are 'activation', 'threshold', 'fatigue', and also the term 'inhibition'. In psychological models increases in response latency that can be observed in Stroop, lexical decision, matching, and sentence completion tasks have been labelled as inhibition even though the various effects may be very distinct in origin. For example, using a Stroop color naming task, Neill (1977) observed that when successive trials were related such that the color word in trial n was the ink color in trial n+1, naming latencies were longer in trial n+1 than in a control condition where there was no relation between successive trials. Neill proposed that in the Stroop task codes for both the color word and the ink color names were automatically activated, and to facilitate a response, inhibitory processes actively suppressed the color word name in trial n. He argued that the effects of these inhibitory processes extended into trial n+1 rendering the ink color name less accessible.

The selective or specific inhibitory processes proposed by Neill differ from the general inhibition discussed by Posner and Snyder (1975) in that specific inhibition refers to the suppression of specific items in memory. General inhibition is a product of attention in which all things not currently focussed on or attended to are inhibited. That is, responses to unattended items exhibit a cost or increase in processing time relative to neutral controls. For example, if subjects are given a matching task, and are led to expect specific types of stimuli when they are cued with a particular item, reaction times will be faster when the cue is valid than when it is neutral and provides no expectancy information. Conversely, if the cue is invalid, a 'cost' or increase in reaction time relative to a neutral cue will be observed. This cost is an effect of general inhibition.

Specific inhibitory views bring into question some traditional conceptions about automatic processes. Models of memory and attention have postulated that the activation of a concept in memory automatically triggers a spread of excitation to semantically related concepts (Collins & Loftus, 1975; Posner & Snyder, 1975). Lexical decision experiments (e.g. Meyer & Schvaneveldt, 1971) and Stroop color naming tasks (e.g. Stroop, 1935; Klein, 1964) support the notion that excitation of the nodes occurs automatically, that is, without awareness or conscious control. Recently, however, evidence has accumulated suggesting that automatic processes may be not only facilitatory but also inhibitory in nature. That is, there may be automatic processes analogous to semantic activation but which behave antagonistically to them. Although there is still controversy over the existence of automatic inhibitory processes, Neill's results (1977) in combination with ambiguous word studies of other investigators provide some support for such inhibitory processes.

Ambiguity refers to the characteristic of some items, such as words or sentences, to have at least two distinct interpretations. MacKay (1970) has described a perceptual suppression theory addressing comprehension of ambiguous sentences which calls for inhibition of one interpretation for comprehension of the other. He also adds that the time to suppress one meaning varies with its salience in the surrounding context. If one meaning is less salient, it will be suppressed more quickly and allow faster comprehension of more salient meanings. Marcel (1980) also argues that inhibition is necessary in

achieving a conscious representation of an ambiguous lexical item. He states that all meanings are accessed preconsciously and that context determines what meaning is to be represented in consciousness. He adds that "inhibition is consequent upon or synchronous with conscious access, but not prior to it." (p. 453)

Existing evidence indicates that multiple meanings of an ambiguous word are accessed when the word appears in isolation (Holly-Wilcox & Blank, 1980; Rubenstein, Lewis & Rubenstein, 1971), but a different picture emerges when an ambiguous word is preceded by a context that biases its interpretation towards one of its meanings. For instance, Schvaneveldt, Meyer and Becker (1976) presented subjects with a series of word/target triplets in which the second word was ambiguous and the first and third words were in some way related to it. The subject's task was to perform a lexical decision on each target. Schvaneveldt, et al. found that lexical decisions for the third word were faster when the first and third words were related to a common meaning of the intervening ambiguous word (e.g. MONEY-BANK-SAVE). Comparable facilitation was not observed when the words were related to different meanings (e.g. RIVER-BANK-SAVE). Marcel (1980) obtained similar results when subjects performed lexical decisions on only the first and third target word.

Studies such as these have contributed to the debate over the role of context in word recognition and comprehension. Two general views have emerged: 1) Context directs the access of lexical items so that only the contextually appropriate meaning is activated and 2) All meanings are accessed independently of context. The former view challenges some common conceptions about the automaticity of semantic activation while the latter is more compatible with complete automaticity. This debate can easily be resolved if one assumes that all associates are accessed initially, and inappropriate readings are subsequently made less available by inhibitory processes.

Data in support of a multiple access theory can be found in the phoneme monitoring experiments of Foss (1970) and Foss and Jenkins (1973). Longer monitoring times were observed when the target phoneme followed an ambiguous word regardless of the preceding context. They interpreted this as an indication of increased processing loads due to either the initial activation of all meanings and/or the decision process involved in selecting the appropriate reading. In a more direct test of activation, Conrad (1974) presented evidence of multiple activation using a biasing sentence context and a Stroop-type color naming task. Subjects heard sentences ending with an ambiguous word, such as 'The beans were cooking in the pot.' and then immediately performed a color naming task on words related or unrelated to the ambiguous word. Both meanings of the ambiguous word interfered with the color naming task even though subjects were consciously aware of only one meaning. Thus, Conrad's results indicate that all meanings of an ambiguous word are activated early on in processing.

At another level, Marcel (1980) investigated the conscious and preconscious activities in word recognition using a sequential lexical decision task similar to Schvaneveldt, et al. (1976). Using a pattern mask, Marcel prevented conscious processing of the ambiguous word. In this condition subjects exhibited activation of all related meanings of the ambiguous word regardless of the context. But when subjects were conscious of the ambiguous item, only the contextually appropriate meaning showed signs of activation, replicating Schvaneveldt, et al. (1976), cited earlier. Marcel's study in combination with Conrad's data lends support to processing sequences in which all meanings are accessed independently

of context, and then all but one are inhibited shortly afterwards. More conclusive support, however, comes from time course studies (e.g. Onifer & Swinney, 1981; Swinney, 1979; Tanenhaus, Leiman & Seidenberg, 1979). For example, immediately following an ambiguous word in a sentence, priming is observed for all meanings, but after about 600 msec Tanenhaus, et al. (1979) found facilitation for only the contextually appropriate meaning. It is possible that the activation decays quickly unless the source of its activity is actively maintained, however, Hudson and Tanenhaus (1984) have demonstrated that it is unlikely that activation for inappropriate meanings would have passively decayed within this period. These time course studies suggest that meanings inappropriate with the current context are made less available through inhibitory processes. Although these data support the notion of specific inibitory processes, they are also compatible with the attentional view of general inhibition. The purpose of the experiment to be reported here is to identify some of the processes involved in resolving lexical ambiguities and also to shed some light on the controversy over the existence of automatic inhibitory processes.

In more specific terms the general inhibitory or attentional theory proposes that one meaning is more accessible because of the focus of attention. Automatic processes activate all meanings of a homograph, but to select a reading, attention quickly focusses on one at a cost to other meanings. Attention can be very focussed with a certain amount of capacity allocated to a relatively small set of codes, or attention can be more diffuse with the same amount of capacity distributed across a much larger set. Thus, when presented an ambiguous word, a person may have attention very committed to one interpretation or more diffusely focussed on several interpretations. If the ambiguous word is presented within a related semantic context -- for example, 'RIVER-BANK' or in a sentence -- then attention is likely to be cued to and focussed on interpretations that are congruent with that context. If no semantic context is provided, then attention will be more diffuse. In these cases other factors such as strength of association or dominance of meaning may influence the ultimate direction of attention, but for this study only the presence of a semantic context is being examined in determining the focus of attention and, thus, the selected meaning of an homograph.

With attention cued to one area of semantic memory, identification of and responses to words within that location should be faster, as in MONEY-BANK-SAVE. However, when a contextually conflicting word is presented, as in RIVER-BANK-SAVE, additional steps must be performed before a response can be made. Attention must disengage itself from the RIVER-BANK locus, shift, and engage at an area representing a MONEY interpretation of BANK. The more focussed attention is on the initial reading, the more difficult it will be and the more time it will take to complete these steps. Consequently, when attention has shifted and a response is to be made, the semantic activation originating from the ambiguous word fails to speed up reaction times relative to unrelated controls because the 'move time', in essence, masks any facilitatory effects. In addition, a certain degree of stimulus processing may occur during the shift of attention so that once the move is completed only the execution of the response remains. This may explain why responses to contextually inappropriate meanings are not substantially slower than unrelated control words (e.g. Schvaneveldt, Meyer & Becker, 1976). This situation gives the appearance of single rather than multiple access.

In summary, the attentional theory proposes that one meaning remains more accessible for active processing because of the focus of attention. Attention quickly focusses on one of several activated meanings at a cost to the others. The unselected meanings suffer a cost because using them would require a time consuming shift of attention. Hence, the attentional view accounts nicely for the time course results, since interpreting the context and focussing attention on the selected meaning take time. The selective inhibition view also assumes that all meanings are activated, but in addition it proposes that the activation of contextually inappropriate items can be directly suppressed soon afterwards.

The paradigm chosen to distinguish between these two views is very similar to the Schvaneveldt, et al. (1976) experiment described earlier except for one additional factor referred to as the 'separated' factor. The inclusion of this factor is based in part on the notion that semantic priming between related words persists even when their presentation is separated by an unrelated item. Several investigators have indicated that semantic activation can carry over in such a manner (Marcel, 1980; Meyer, Schvaneveldt & Ruddy, 1972; Schvaneveldt, et al., 1976). Subjects for the present study were presented sequences of four related and/or unrelated items in which the second word was always ambiguous. If a related target appeared directly after the ambiguous word the trial was called unseparated. This situation is most like the Schvaneveldt et al. (1976) study. In the unseparated trials the fourth item was an unrelated filler item. If a target related to the ambiguous word appeared as the fourth item, the trial was called separated and an unrelated filler target appeared as the third item. Hence, critically related targets appeared as the third item in unseparated trials and as the fourth item in separated trials (see table 1). Crossed with the separated factor were four relatedness conditions.

Insert table 1 about here.

In the congruent condition the critical words preceding and following the homograph were related to common meanings. In the unbiased condition the word preceding the homograph was unrelated to it, while the critical word after the homograph was related to it. In the incongruent condition the critical words before and after the homograph were related to different meanings. And in the control condition all items in the sequence were unrelated.

With this design and appropriate time intervals both explanations predict selective facilitation in the unseparated case. This result would be a replication of the Schvaneveldt, et al. data (1976). In the separated conditions, however, the general inhibitory view predicts more or less equivalent facilitation in the responses for all related targets, whereas the selective inhibition view predicts continued selectivity of meaning. The pattern predicted under the general inhibitory view is expected because this view holds that nothing has interfered with the initial activation of related meanings. Consequently, if attention is first shifted away from the focussed meaning to a neutral item, and then shifted back to any of the previously activated meanings of the homograph, comparable amounts of facilitation should be observed for all of them. The selective inhibition view, however, proposes that a direct suppresion of the activity at

inappropriately related items occurs. Hence, once the excitation is suppressed, responses to contextually inappropriate words should be slower or at least equal to unrelated controls.

Preliminary Experiments

The conclusions drawn from several preliminary studies helped determine the procedures used for the present study. Using the same experimental conditions described above, subjects were presented trials in which the first two items were always English words. The first word appeared on the screen before the second word came on directly beneath it. Both words remained on the screen for a short while followed by a blank display. In the experimental trials the second word was always an ambiguous word and the first word served as a prime. Subjects were not required to make an overt response to these words. They were only told to read these words to themselves silently. After a short pause the third item was presented, and subjects made a lexical decision response to these items. Once a response was made the stimulus disappeared and a second lexical decision target was presented. On half of these trials the critical target was the third item and on the other half it was the fourth item. Half of the time the critical targets were related to the ambiguous word and half of the time they were unrelated. The results suggested that the semantic relationships between the contexts and targets had little or no effect on processing times, which was very surprising.

Because the pattern of results observed was very much unlike those presented in the literature, it seemed possible that any effects due to experimental condition were only occurring on some proportion of the trials and not on others. It is possible that some words could have been recognized as words so easily and so quickly that context would not have any effect. On other trials, however, perhaps subjects could not immediately access a word, and in these instances context would show a stronger effect. This idea reflects the finding by some researchers that context has a greater influence on slow readers, that is, those people with slower direct access to lexical items (Stanovich & West, 1981), and that context has a greater effect on performance when the stimulus is degraded -- an experimental manipulation which retards recognition processes (Meyer, et al., 1972).

For example, Perfetti, Goldman and Hogaboam (1979) found that slower, less skilled readers seemed to use contextual information for word recognition more than very skilled readers. Poorer readers are less likely to have fast direct access to words in memory, hence the use of other strategies or processes can come into play to influence the retrieval of items. In addition, Stanovich and West (1981) demonstrated that difficult and less predictable words exhibited much larger context effects than easier, more predictable words. Here again, it is likely that the easier items had much faster access to their representations in memory, thereby minimizing their chances of being influenced by context.

To pursue this notion an additional analysis was performed on the pilot data based on the rationale that only a portion of a subject's trials were significantly affected by context, because, for whatever reason, they were more difficult to process, or they were processed differently than other trials. This was supported in the data. In this analysis each subject's reaction times were split into two halves on either side of his or her median score. The extreme fastest and slowest scores were then discarded to reduce the effects of outlying scores.

The remaining reaction times were then averaged to give a mean fast and slow score for each subject in each condition.

All of the same effects shown with the median analysis were observed with this analysis, except a stronger main effect of condition was observed in the slow trials. The pattern with fast reaction times was essentially flat across all conditions, whereas the slow reaction times exhibited stronger priming effects. There was, however, no interaction between relatedness condition and the separated factor for either set of data indicating that the pattern of activation did not change when a separating neutral item was introduced.

Examination of the slow trials revealed a pattern of general facilitation, but the ordering of the facilitation effects in the relatedness conditions was in line with predictions of selective facilitation. The amount of facilitation when reaction times are collapsed across the separated factor were greatest for the congruent condition followed by the unbiased condition and then the incongruent condition. Statistical tests revealed, however, that only the congruent trials were reliably faster than the unrelated controls. But because the congruent reaction times did not differ from the incongruent times, it was unclear whether or not any inhibitory processes -- either general or specific -- operated in these pilot experiments. Consequently, the data obtained were not appropriate for making the intended comparison between the specific and general inhibitory views. But they did support the claim that related contexts show stronger effects in trials where responses are slower.

One explanation for the failure to obtain stronger context effects may lie in the task required of subjects. Henik, Friedrich and Kellogg (1983) have presented data suggesting that the quality of prime processing may be a critical factor in obtaining priming effects. Since the type and extent of prime processing was not explicitly controlled in these preliminary studies, it was possible that subjects did not process the primes very 'deeply' and may have fallen into a rhythm using the first two items in a trial as countdown cues for the lexical decision targets. If this were the case, then one would expect only very weak effects of context. Thus, the preliminary studies suggest that when subjects simply read priming words and perform no overt task, priming effects are elusive and only become apparent in the slower trials of a subject's session. The present experiment was intended to prevent this from happening by requiring subjects to perform a lexical decision on all items in a trial. Because experimental trials consisted of primarily word targets, it seemed important to reduce the salience of related exerimental trials with this new design. Consequently, the testing sessions of the present experiment were structured so that the beginning of a new trial could not be detected. The onset times for an item within a trial was the same as the onset time for a new trial. Thus, subjectively the trials were not discrete.

Method

Subjects. Subjects were 32 individuals recruited from a pool of volunteers at the Center for Cognitive Studies at the University of Oregon. All subjects were native English speakers with normal or corrected vision and no apparent reading disabilities. Subjects received $4.00 for participating in the one hour experiment.

Design. This experiment used a 4 x 2 factorial within subjects design with one factor corresponding to relatedness (4 levels: congruent, unbiased, incongruent, and unrelated controls) and the other to the presence or absence of a separation between the second word in a four item sequence and the subsequent related target (2 levels: separated and unseparated). The separation was achieved by presenting a neutral stimulus before the related target.

Sixteen different lists were compiled in which the 120 ambiguous words were divided into eight conditions: congruent-separated, unbiased-separated, incongruent- separated, control-separated, congruent-unseparated, unbiased-unseparated, incongruent-unseparated and control-unseparated. With this grouping the control trials contained an ambiguous word in the same position as the related trials, however all items were unrelated to each other. One of the lexical decision targets in each of the control trials was taken from the pool of targets that were related to ambiguous words in the overall study, but were not used as related targets in the current subject's session. In this way, target words served as related targets and unrelated controls an equal number of times across subjects. In half the trials these targets were presented in the third position and in the other half in the fourth. The neutral items in the separated trials (the third items) were always words, and in the unseparated trials the neutral items (the fourth items) were always nonwords. The critically related target was never immediately preceded by a nonword. The neutral item in the unseparated trials were always nonwords because it helped balance the proportion of word and nonword responses made by the subjects. Since the nonwords followed the critical items of interest it could have no effect on lexical decisions to the word targets. Also included in the lists were 126 filler trials with different combinations of word and nonword targets.

Materials and apparatus. Presentation of stimuli and collection of responses were performed by an Apple II+ computer system.

Stimuli consisted of 120 ambiguous words having at least two strongly associated but different meanings chosen from various homograph association norms (Cramer, 1970; Gorfein, Viviani & Leddo, 1982; Nelson, McEvoy, Walling & Wheeler, Jr., 1980; and Perfetti, Lindsey & Garson, 1971). The mean frequency of these words was 76.4, s=118.0. All word frequency counts were taken from Kucera and Francis (1967). For each ambiguous word four highly associated words were chosen from the norms: two words from each of the two meanings strongly associated to the ambiguous word. Because each stimulus word was to appear only once throughout an experimental session, some entries in the norms were disqualified. In these cases the experimenter provided equivalent substitutions. Two of the chosen words, one from each meaning, were only used as contextual primes, and the remaining two words only served as lexical decision targets. No more than one of the primes and one of the targets were used in any trial with a related ambiguous word. The mean word frequencies for these stimuli were 94.8,

s=117.2 for one pool of primes; 88.8, s=169.8 for the second pool of primes; 121.8, s=279.8 for the first pool of targets and 92.2, s=175.7 for the second pool of targets.

Sixteen different lists were compiled so that the two meanings of ambiguous words were probed an equal number of times in all the relatedness and separated combinations across subjects. The 120 ambiguous words were divided into six relatedness conditions for each list (congruent, incongruent and unbiased crossed with separated and unseparated), and whichever targets were not used as related targets within a list were used as critical control items. The primes that were not used with their related ambiguous word served as neutral items for other trials. Stimulus words (560) for the remaining control and filler items were picked at random from Kucera and Francis (1967). The items for the nonword filler trials were randomly selected from Kucera and Francis (1967). In creating nonword stimuli, the vowels in randomly selected English words were exchanged for others to maintain pronounceability.

In summary, there were 246 trials in this experiment: 120 experimental and control trials and 126 filler trials. Each subject was presented a trial testing a particular ambiguous word only once, but across subjects both meanings of an ambiguous word were probed an equal number of times in each condition. All ambiguous words appeared in each condition an equal number of times and all targets were probed an equal number of times in each condition across subjects.

Procedure. In this experiment subjects performed a lexical decision on every item. The trials were structured so that subjects performed lexical decisions on long lists of targets presented one word at a time. That is, the time between items within a trial was the same as the time between trials. Subsequently, trials were not discrete, and so were indistinguishable by subjects. Thus, subjects were less likely to be aware of a group of related items and less likely to develop expectancies for word/nonword response patterns.

After a practice session of 24 trials, subjects were tested in three blocks. Between each block of 82 trials they were given rest periods. Each block began with a 'READY?' message to which subjects pressed a response key to begin. Targets were presented in the center of the screen and remained there until a response was made. There was a blank period of 1000 ms and then the next target was presented. This sequence continued until the end of a block at which point another 'READY?' message appeared. Subjects made responses with one hand. A left key was pressed for 'word' responses and a right key for 'nonword' responses. The time between target presentation and a subject's response was recorded by the computer.

Results and discussion

All trials in which subjects made an error before or on the critical lexical item were excluded from analyses. The mean proportion of trials on which subjects erred in each condition are presented in table 2. Analysis of the error rates revealed no significant main effects of the related or separated factors, but it did indicate a statistically reliable interaction between these two ($F(3,93) = 2.92$, $p<.04$). This interaction is probably due to the high proportion of errors in the UB-S condition. Proposed explanations for this interaction would be purely conjecture at this point, since no interaction was observed in any of the previous pilot studies performed. Consequently, one is inclined to interpret this result as

simply an experimental artifact -- chance variation -- although such conclusions may be premature.

Insert table 2 about here.

The averages of each subject's median reaction times to critically related items in each condition were calculated. These values are presented in figure 1. Statistical analysis of these data revealed a main effect of relatedness ($F(3,93) = 5.19$, $p<.003$), but no main effect of the separated factor ($F(1,31) = 0.31$) and no interaction between separated and relatedness ($F(3,93) = 1.579$).

Insert figure 1 about here.

The pattern of reaction times obtained in this experiment suggests that selection of a meaning had occurred. That is, a contextually inappropriate meaning showed less priming than a contextually appropriate meaning in both the separated and unseparated cases. Since there is no sign of an interaction, it seems that the presence of the neutral item did not produce a change in the pattern of reaction times. This result is not compatible with the general inhibition view, and although the data are in line with the specific inhibition hypothesis, more convincing evidence would be the observation of reaction times that were reliably slower in the incongruent-separated condition than in the comparable control condition. Consequently, a fast versus slow analysis of the reaction times was performed as in the preliminary experiments. It was thought that perhaps related contexts had differential effectiveness in this experiment, as it had in pilot studies. If this were the case, then strong signs of specific inhibitory processes might be present in the slower incongruent trials and not in the faster trials where context might be less effective. If these trials were then averaged together, an effect might be obscured. The results of this analysis can be seen in figure 2.

Insert figure 2 about here.

The analysis of fast responses revealed a significant main effect of condition ($F(3,31) = 3.04$, $p<.04$), suggesting that the selective results observed with the medians is robust. No other effects were reliable in the fast analysis. With slow responses a main effect of relatedness condition was observed ($F(3,31) = 2.98$, $p<.04$), as well as a marginally significant interaction between the relatedness and separated factors ($F(3,93) = 2.47$, $p<.07$). The responses to contextually incongruent trials were much slower than controls in the separated trials. Again, context appears to have influenced the slower trials to a greater degree than the fast trials.

The pattern of reaction times in the slow trials provides additional support for the notion that the selectivity of meaning observed in ambiguous word studies

is not due to attention focussing on particular meanings at the expense of others. The attentional view predicts comparable reaction times for all meanings of a homograph in the separated trials, because the neutral item should introduce a break in the focus of attention, and allow any residual semantic activation to speed up responses to all related meanings. Since the data show that responses for the incongruent condition are even slower than in control trials when a neutral item intervenes, this view is not supported. The observed interaction suggests that selective inhibitory processes may have suppressed the automatic activation of incongruent items. These inhibitory processes may develop slowly in comparison to automatic activation processes because they seem to be much stronger in the slower trials of a subject as well as in the separated trials -- trials where the critical target appears even later in time than the unseparated trials.

One point concerning the secondary analyses performed in this experiment deserves mention. Considering the painstaking effort put forth by experimenters to counterbalance lexical stimulus items, it seems important to justify comparing different items based simply on their relative reaction times and to determine why context would affect some items differentially. The rationale for performing the analyses was based on the notion that some items may have been more difficult to process than other items. Perhaps low frequency words were more difficult and were responded to more slowly than high frequency words, or perhaps dominance of association was the crucial factor. A more detailed examination of what may have caused these different patterns in fast and slow scores revealed that the observed pattern could not be attributed to the word frequency of the target or to the associational dominance of the targets meaning to the homograph.

Two analyses were performed on the data from the experiment in which the reaction times were split into high (greater than 30) or low (less than or equal to 30) frequency target groups and high or low dominance target groups. Mean reaction times for each subject in each condition were obtained for high and low frequency targets and for higher and lower dominance targets. Although the alternate word meanings used in these experiments were all strongly associated to their paired homograph, inevitably one member of each pair was associated more strongly than the other. Analyses of the high and low frequency breakdown revealed a main effect of frequency with high frequency words being responded to more quickly than low frequency words. The mean reaction time for the high frequency words was 552 ms and 626 ms for the low frequency words ($F(1,31) = 38.84$, $p<.001$). There was also a marginally significant main effect of condition that was consistent with the selective pattern observed with the other analyses ($F(3,93) = 2.61$, $p<.06$). No other significant effects were observed. Because this breakdown failed to produce significant interactions, it seems that the effects observed with the fast/slow analysis cannot be attributed to the frequency of the targets.

The analysis of the dominance breakdown only revealed a main effect of the dominance factor with responses to dominantly associated targets being reliably faster than responses to less strongly associated targets. The mean response time to more strongly associated targets was 580 ms, and for less strongly associated targets it was 597 ms ($F(1,31) = 4.91$, $p<.04$). Hence, this analysis also failed to account for the pattern of results obtained with the fast and slow breakdown. Thus, little consistency appeared between subjects as to what constitutes 'difficult' items. Thus, the fast/slow division remains as the

dimension capable of reliably identifying the more difficult items that exhibit stronger context effects.

General Discussion

This experiment presents a useful method for distinguishing between the general and specific inhibitory explanations for ambiguous word studies. The evidence indicating that reaction times to contextually incongruent targets in the separated trials were not faster or equal to but even slower than unrelated controls suggests that specific inhibitory processes suppressed the activation of those concepts. The effect was not caused by any general inhibition produced by the focus of attention, since this view predicted comparable facilitation for all meanings.

When comparing the conditions surrounding the lexical ambiguity studies (e.g. Marcel, 1980; Onifer & Swinney, 1981; Swinney, 1979; Tanenhaus, Leiman & Seidenberg, 1979) and the Stroop studies (Neill, 1977) that support the automatic inhibitory notion, several common aspects arise. First, in both situations there is activation of multiple codes. In the ambiguity studies there is activation of the different word meanings, and in the Stroop studies there is activation of both the color word and the ink color. When this occurs, attention may select one of the codes for continued processing. In Stroop studies the unselected code is the printed word, and in lexical ambiguity studies the unselected codes are all of the inappropriate meanings. Consequent upon making this selection, automatic inhibitory processes may be triggered for the unselected codes.

Thus, it is possible that attention mediates selective inhibitory processes, although it in itself may not be the primary source of the inhibition. Just as semantic activation may require some degree of attention to observe effects (Henik, et al., 1983) automatic inhibitory processes may also require some attentional precursor. This is further supported by the fact that the selective pattern was observed only when subjects performed lexical decisions on all the items in a trial, and not in preliminary experiments when they simply read the priming words as they flashed on the screen. Hence, attention may serve to trigger the specific inhibitory processes that suppress a meaning. From this, a model of specific inhibition emerges in which there are three stages. The first involves multiple activation of codes, the second involves selective attention, and the last is the triggering of inhibitory processes themselves.

In conclusion, this experiment supports the notion that automatic inhibitory processes analogous to semantic activation processes exist in semantic memory. Furthermore, it suggests that these internodal inhibitory processes are largely responsible for the suppression of unselected meanings in lexical ambiguity studies. This is not to say that attention plays no role in the resolution of ambiguities. It is possible that it acts to trigger the selective inhibition for unwanted meanings. To pursue this, it may be interesting to investigate exactly how attention might interact with specific inhibitory processes in this paradigm. One might compare the patterns of activation observed when attention is deflected to neutral items falling between an ambiguous word and a related target to when attention is "free-floating" for equal amounts of time. Such comparisons might determine if there is any significance to actively processing a neutral item for attention to trigger specific inhibition of inappropriate meanings.

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Table 1

Examples of the Stimulus Trials Used

Unseparated

Condition	Item 1	2	3	4
Congruent	BODY	ORGAN	HEART	SHIP
Unbiased	TILT	ORGAN	HEART	SHIP
Incongruent	MUSIC	ORGAN	HEART	SHIP
Control	PINT	BOAST	HEART	SAND

Separated

Condition	Item 1	2	3	4
Congruent	BODY	ORGAN	SHIP	HEART
Unbiased	TILT	ORGAN	SHIP	HEART
Incongruent	MUSIC	ORGAN	SHIP	HEART
Control	PINT	BOAST	SAND	HEART

Note. Critically related targets are underlined.

Table 2

Subjects' Mean Proportion of Trials with Errors

	Unseparated	Separated
Congruent	.06	.03
Unbiased	.04	.08
Incongruent	.06	.05
Control	.06	.06

Figure Captions

Figure 1. Means of subjects' median reaction times to critical targets in each condition.

Figure 2. Means of subjects' fast and slow reaction times to critical targets in each condition.

Figure 1

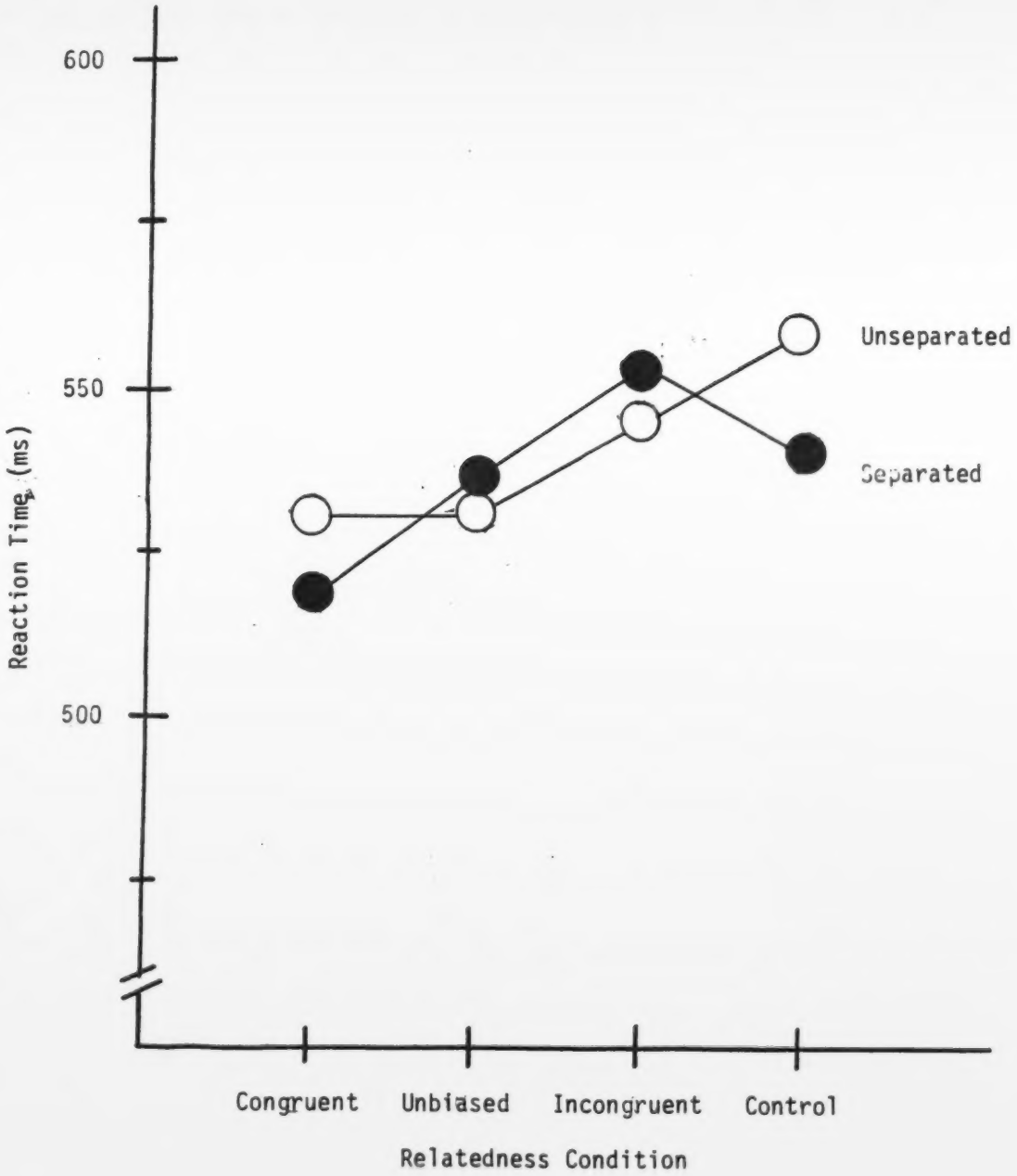
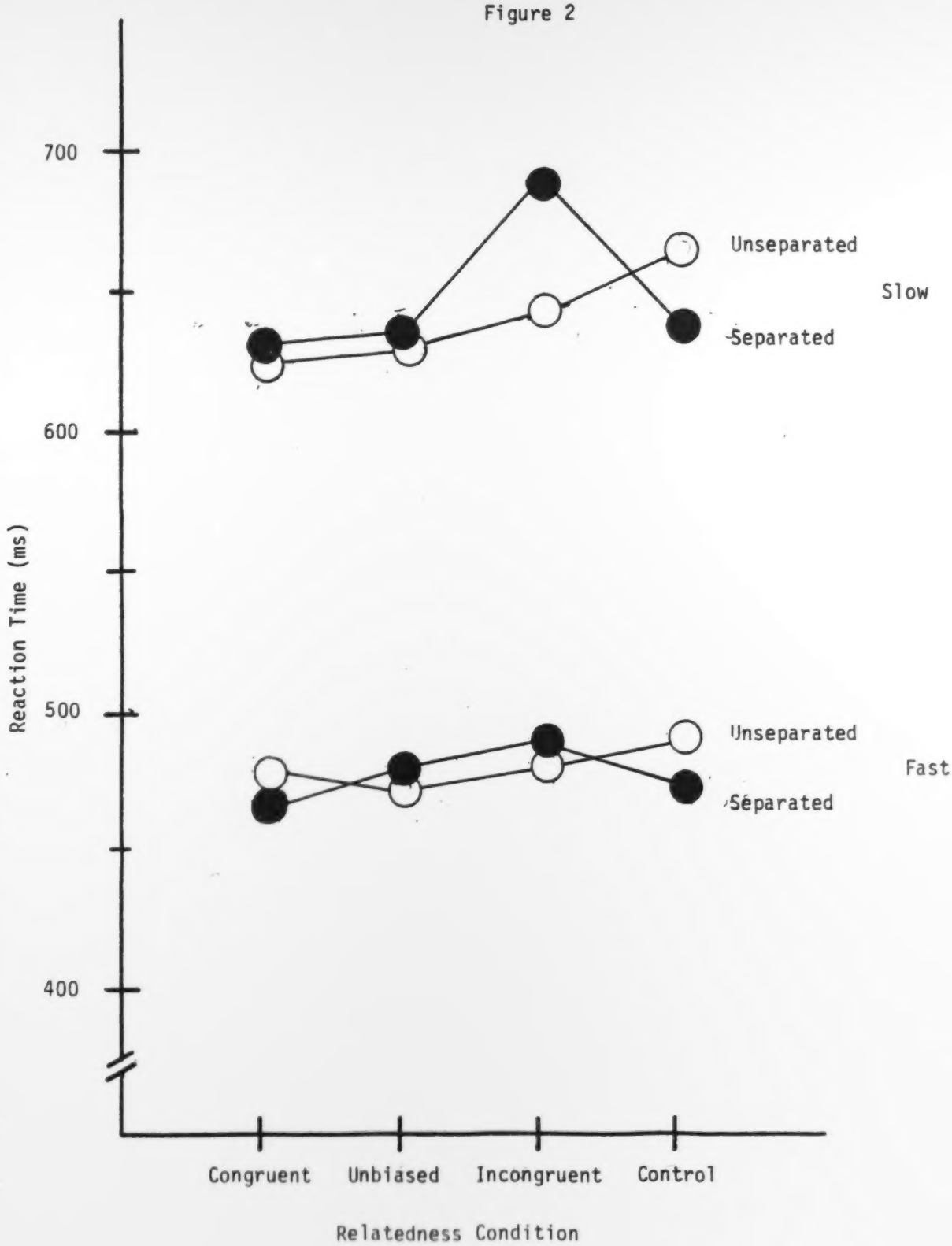

600
550
500
Reaction Time (ms)
Unseparated
Separated
Congruent
Unbiased
Incongruent
Control
Relatedness Condition

Figure 2


700
600
500
400
Reaction Time (ms)
Unseparated
Separated
Slow
Unseparated
Separated
Fast
Congruent
Unbiased
Incongruent
Control
Relatedness Condition